Immunochemistry. The Application of the Principles of Physical Chemistry to the Study of the Biological Antibodies. By SVANTE ARRHENIUS. New York, The Macmillan Company. Pp. 309. $1.60.

During the last year Arrhenius has published three books which, in the opinion of the reviewer, embody the most advanced results and conceptions of modern science in a classical form. Those who are interested in the methodology of science and the theory of cognition will learn by what methods those scientists, of whom Arrhenius is a representative, are able to build on certainty instead of upon the vague basis of hypothesis; and those who doubt whether or not we have reached any definite conception of the nature of matter will find authoritative information in the books of Arrhenius. These books are: (1) "The Theories of Chemistry," (2) "Das Werden der Welten," (3) "Immunochemistry." The English edition of the latter has just appeared and it is to this that we wish to call special attention.

After Metchnikoff had made the attempt to explain the phenomena of immunity by phagocytosis Ehrlich showed that immunity is due to a chemical reaction between toxin and antitoxin. With the clear foresight which has characterized the scientific career of this brilliant investigator he saw that the ultimate proof for the correctness of the purely chemical conception of the phenomena of immunity could only be furnished by the physical chemist. Through the influence of Madsen, Arrhenius was induced to undertake this task. Partly alone, partly in collaboration with Madsen and his school, he solved the problem in the only way on which it could be solved—namely, by showing that the action of the antitoxin upon the toxin followed the law of Guldberg and Waage. In the execution of this task he adopted the principles of eliminating the unnecessary and disturbing variables and presenting the results as the function of the minimal number of independent variables. The fact that this principle is not sufficiently appreciated by biologists has led here, as in all similar cases, to some opposition. It is, however, obvious that if a variable has been overlooked its effects can easily be added to the results; while without an attempt at the utmost simplification in the beginning no start and no progress would have been possible.

The writer of this review would especially call the attention of the younger biologists to the importance of a study of Arrhenius's books.

JACQUES LOEB

The Electrical Conductivity of Aqueous Solutions. A Report presented by ARTHUR A. NOYES, W. D. COOLIDGE, A. C. MELCHER, H. C. COOPER, YOGORO KATO, R. B. SOSMAN, G. W. EASTMAN, C. W. KANOLT and W. BÖTTGER. Contribution from the Research Laboratory of Physical Chemistry of the Massachusetts Institute of Technology No. 19. Carnegie Institution of Washington, Publication No. 63. Pp. vi + 352.

This volume is a report on a monumental series of investigations which have been in progress in Professor Noyes's laboratory during the past five years upon the electrical conductivity of aqueous solutions of certain salts, acids and bases through a wide range of temperatures extending from 18° to 306°. The work was undertaken with the expectation of studying the properties of aqueous solutions at temperatures up to the critical temperature and beyond, a task burdened with very serious difficulties, as will be realized when one recalls that the critical temperature of water is in the neighborhood of 360°, and that at this temperature the conductivity cell must not only safely withstand a pressure of something like 200 atmospheres without leaking and without contaminating the dilute solutions employed, but must also do this under such conditions as will permit accurate control of the temperature, volume and conductivity of the solutions.

Up to the present time the highest temperature reached is 306°, but to one who studies the ingenious manner in which the experimental difficulties have so far been overcome there can be no doubt that the original plan will be ultimately realized.

Among the important results presented in this volume are data showing the effects of

widely varying temperature conditions on the specific volumes of water and water solutions, on the equivalent conductivities of electrolytes, on the specific migration velocities of the ions, on the degree of ionization of various solutes, on the self-ionization of water and on hydrolysis.

The effect of rising temperature is to enormously increase the equivalent conductivity of aqueous solutions and the speed with which the ions travel in such solutions, the speed of the latter continuing to increase even after the equivalent conductance has reached a maximum value, thence to decline with rising temperature. The significant observations have also been made that the specific velocities of all monovalent ions tend toward equality with rising temperature, while divalent ions approach a value double that of monovalent ions. These tendencies, together with the effect of rising temperature on conductance, are illustrated by the behavior of potassium chloride and hydrochloric acid. The equivalent conductances of potassium chloride and hydrochloric acid, extrapolated for zero concentration, which at 18° are respectively 130.1 and 379.0 reciprocal ohms, have been found to be 1,120 and 1,424 respectively at 306°.

Various investigators have called attention to the fact of a connection between the viscosity of the solvent and ionic velocities. It is shown in these investigations that the conductance of salt solutions increases with rising temperature at practically the same rate as the fluidity of the solvent, at any rate up to 156°, which is the limit to which viscosity measurements have been made.

Increase of temperature has been found to be accompanied by a marked diminution of the ionization of the solute and especially at higher temperatures the rate of decrease becomes very great. For example, in a 0.01 normal solution of hydrochloric acid, the percentage ionization at 18° is 97.1, while at 306° it is but 82 per cent. Of an 0.08 normal solution of potassium sulfate, 73 per cent. of the solute is present as ions at 18°, while at 306° only 23 per cent. is present in the ionic condition. The effect of rise of temperature on the dissociation of weak acids and bases is even more marked, as is shown by the change of the affinity constant of acetic acid from 0.0000183 at 18° to 0.000000139 at 306°, and of ammonium hydroxide from 0.0000172 at 18° to 0.000000093 at 306°.

In view of the diverse opinions which have been expressed concerning the connection between the dielectric constant of a solvent and its ionizing power, it is interesting to note that these researches show that the ratio of the concentration of the un-ionized portion of the solute at two different temperatures (at least up to 100°, the limit to which the dielectric constant of water is known) agrees very well with the ratio of the dielectric constants for the same temperature interval.

Since the equivalent conductance of an electrolyte is a function of two variables, specific speed of the ions and the degree of ionization, and since the effect of changing temperature on the ionization is most conspicuous at higher temperatures, it follows that the equivalent conductance must pass through a maximum value thence to diminish continuously towards zero as the temperature passes the critical point. This maximum has been realized in the case of a considerable number of solutes, especially in the more concentrated solutions.

Quite contrary to the influence of rising temperature in diminishing the dissociation of electrolytes in solution is the effect on the ionization of water itself. The ionization constant of water rises with tremendous rapidity up to 100°, thence more slowly, reaching a maximum value over 5,000 times the value at zero, after which it decreases with further rise of temperature. This great increase in the ionization of water with rising temperature, together with its weaker ionizing effect on electrolytes in solution, accounts for the enormously greater tendency of salts to hydrolyze at higher temperatures.

As at ordinary temperatures, so also at higher, the mass law does not apply to solutions of salts, strong acids and bases. On the other hand, the applicability of the law to weak acids and bases has been shown to be independent of the temperature. In this con-

nection it is important to note that in the summary to this series of papers Dr. Noyes expresses his conviction that "the ionization of salts, strong acids and strong bases is a phenomenon primarily determined not by specific chemical affinities, but by electrical forces arising from the charges on the ions, that it is not affected, excepting in a secondary degree by chemical mass action, but is regulated by certain general, comparatively simple laws, fairly well established empirically, but of unknown theoretical significance, and that, therefore, it is a phenomenon quite distinct in almost all aspects from the phenomenon of dissociation ordinarily exhibited by chemical substances, including that of the ionization of weak acids and bases."

It is scarcely necessary to emphasize the importance of such a study of aqueous solutions as Professor Noyes has inaugurated, for, in addition to the direct physical and chemical significance of the knowledge thus to be gained, every one will recognize the importance of such investigations in their bearing on certain phases of chemical technology and chemical geology.

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SCIENTIFIC JOURNALS AND ARTICLES

THE opening (January) number of volume 9 of the *Transactions of the American Mathematical Society* contains the following papers:

F. L. GRIFFIN: "Certain periodic orbits of k finite bodies revolving about a relatively large central mass."

G. H. DARWIN: "Further note on Maclaurin's spheroid."

O. D. KELLOGG: "Potential functions on the boundary of their regions of definition."

O. D. KELLOGG: "Double distributions and the Dirichlet problem."

G. A. MILLER: "Groups defined by the orders of two generators and the order of their commutator."

E. J. WILCZYNSKI: "Projective differential geometry of curved surfaces. (Second memoir.)"

The February number (volume 14, number 5) of the *Bulletin of the American Mathematical Society* contains: Report of the First Regular Meeting of the Southwestern Section, by O. D. Kellogg; "Note on the Composition of Finite Rotations about Parallel Axes," by Alexander Ziwet; "On an Integral appearing in Photometry," by A. S. Chessin; "Hermitian Forms with Zero Determinant," by J. I. Hutchinson; "Two Tetraedron Theorems," by H. S. White; "Singular Points of a Simple Kind of Differential Equation of the Second Order," by C. A. Noble; "The Theory of Electricity" (review of Abraham's Theorie der Elektrizität, volume 2), by E. B. Wilson; "Notes;" "New Publications."

The March number of the *Bulletin* contains: Report of the Fourteenth Annual Meeting of the Society, by F. N. Cole; Reports of the December Meeting of the Chicago Section and of the Joint Meetings at Chicago of Mathematicians and Engineers, by H. E. Slaught; Report of the Fifty-eighth Meeting of the American Association for the Advancement of Science, by G. A. Miller; "Shorter Notices" (Larmor's Memoir of G. H. Darwin, by E. W. Brown; Lambert's Computation and Mensuration, by E. W. Ponzer; Schütte's Darstellende Geometrie für Gymnasien, by Virgil Snyder; Thompson's Petrus Peregrinus, by F. Cajori; Broggi's Traité des Assurances de la Vie, by G. H. Ling); "Notes;" "New Publications."

SOCIETIES AND ACADEMIES

THE SOCIETY OF CHEMICAL INDUSTRY

IN place of the regular meeting of the Society of Chemical Industry on January 24, a joint meeting of the Society of Chemical Industry, the American Chemical Society, the American Electro-Chemical Society, the Chemists' Club of New York City and the Verein Deutscher Chemiker was held for the presentation of the Perkin Medal to Mr. J. B. F. Herreshoff. Mr. George C. Stone was in the chair.

After a few introductory remarks by the chairman, in which he emphasized the importance of stimulating chemical research by proper recognition, and bringing to the attention of the audience the life-work of Sir Perkin, who not only discovered a new product, but worked out its manufacture, developed